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# Nelson Reservoir
# Phillips County, Montana

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

May 77

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# U.S. ENVIRONMENTAL PROTECTION AGENCY
# NATIONAL EUTROPHICATION SURVEY

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# Report
# on
# Nelson Reservoir
# Phillips County
# Montana
# EPA Region VIII
Working Paper No. 798

With the cooperation of the
Montana Department of Health & Environmental Sciences
and the
Montana National Guard
May, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| eutrophication<br>lakes<br>nutrients<br>phosphorus<br>nitrogen<br>loading | | 08H<br>05C |

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# FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

## OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

## ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

## LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) express sincere appreciation to the Montana Department of Health and Environmental Sciences for professional involvement, to the Montana National Guard for conducting the tributary sampling phase of the Survey, and to those Montana wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Bureau provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General John J. Womack, the Adjutant General of Montana, and Project Officer Major William Yeager, who directed the volunteer efforts of the Montana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

# NATIONAL EUTROPHICATION SURVEY
## STUDY LAKES AND RESERVOIRS
## STATE OF MONTANA

| LAKE NAME | COUNTY |
|---|---|
| Canyon Ferry | Broadwater, Lewis and Clark |
| Clark Canyon | Beaverhead |
| Flathead | Flathead, Lake |
| Georgetown | Deer Lodge, Granite |
| Hebgen | Gallatin |
| Koocanusa | Lincoln, MT; British Columbia, Can. |
| Mary Ronan | Lake |
| McDonald | Flathead |
| Nelson | Phillips |
| Seeley | Missoula |
| Swan | Lake |
| Tally | Flathead |
| Tiber | Liberty, Toole |
| Tongue River | Big Horn |
| Whitefish | Flathead |
| Yellowtail | Carbon, Bighorn, MT; Bighorn, WY |

Milk
Nelson Canal
A1
NELSON RESERVOIR
A2
Mont.
Map Location
NELSON RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Km.
Scale
Mi.

# NELSON RESERVOIR

## STORET NO. 3009

## I. CONCLUSIONS

### A. Trophic Condition:

Survey data indicate that Nelson Reservoir is eutrophic. It ranked twelfth in overall trophic quality when the 15 Montana lakes and reservoirs sampled in 1975 were compared using a combination of six water-quality parameters*. Ten of the water bodies had less median total phosphorus, seven had less median dissolved orthophosphorus, nine had less median inorganic nitrogen, 13 had less mean chlorophyll a, and 13 had greater mean Secchi disc transparency. Depression of dissolved oxygen with depth occurred at station 2 in July.

Survey limnologists noted abundant submerged macrophytes during the July sampling and an algal bloom in September.

### B. Rate-Limiting Nutrient:

The algal assay results are not considered representative of conditions in the reservoir at sampling time due to significant changes in nutrients in the samples during shipment from the field to the laboratory.

The reservoir data indicate nitrogen limitation at all sampling stations and times, with the exception of station 1 in July.

* See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known municipal point sources impacted Nelson Reservoir during the sampling year. Septic tanks serving shoreline dwellings were estimated to have contributed 0.2% of the total phosphorus load, but a shoreline survey would have to be conducted to determine the significance of those sources.

The present phosphorus loading of 0.41 g/m$^2$/year is greater than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11).

2. Non-point sources--Non-point sources accounted for 99.8% of the total phosphorus load during the sampling year. The Nelson Canal inlet contributed 95.6% of the total.

Major agricultural land uses in the area include pasturing and crop land as reported by Survey limnologists. Further study is needed to determine the controllability of the nutrient contributions of such sources.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[1]

A. Morphometry[11]:

1. Surface area: 18.46 kilometers$^2$.

2. Mean depth: 5.7 meters.

3. Maximum depth: 8.5 meters.

4. Volume: $105.185 \times 10^6$ m$^3$.

5. Mean hydraulic retention time: 1.8 years (based on 1975 outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

| Name | Drainage area (km$^2$)* | Mean flow (m$^3$/sec)* |
|---|---|---|
| Nelson Canal | - | 2.290 |
| Minor tributaries & immediate drainage - | - | - |
| Totals | - | 2.290 |

2. Outlet -

| | | |
|---|---|---|
| Nelson Canal | - | 0.028** |
| Nelson South Canal | - | 1.869 |
| Totals | - | 1.897 |

C. Precipitation***:

1. Year of sampling: 46.9 centimeters.

2. Mean annual: 30.0 centimeters.

1/ Table of metric conversions--Appendix B.
†† Surface area - Norpested, 1974; volume - Martin and Hanson, 1966.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976"; no drainage areas or normalized flows - canal flow is completely regulated (Pike, 1975).
** Leakage through canal gates.
*** See Working Paper No. 175.

## III. WATER QUALITY SUMMARY

Nelson Reservoir was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at three stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 1.5 meters at station 1, 11.6 meters at station 2, and 5.5 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

| | | |

B. Biological Characteristics:

1. Phytoplankton -

| Sampling Date | Dominant Genera | Algal Units per ml |
|---|---|---|
| 06/30/75 | 1. Chroomonas sp. | 347 |
| | 2. Centric diatoms | 261 |
| | 3. Cryptomonas sp. | 87 |
| | 4. Ankistrodesmus sp. | 43 |
| | 5. Nitzschia sp. | 43 |
| | Total | 781 |
| 07/24/75 | 1. Chroomonas sp. | 523 |
| | 2. Aphanizomenon sp. | 486 |
| | 3. Ankistrodesmus sp. | 75 |
| | Total | 1,084 |
| 09/08/75 | 1. Aphanizomenon sp. | 3,800 |
| | 2. Flagellates | 192 |
| | 3. Chroomonas sp. | 171 |
| | 4. Oscillatoria sp. | 128 |
| | 5. Schroederia sp. | 107 |
| | Other genera | 43 |
| | Total | 4,441 |

2. Chlorophyll a -

| Sampling Date | Station Number | Chlorophyll a (ug/l) |
|---|---|---|
| 06/30/75 | 1 | 1.3 |
| | 2 | 1.5 |
| | 3 | 5.4 |
| 07/24/75 | 1 | 1.5 |
| | 2 | 1.6 |
| | 3 | 1.8 |
| 09/08/75 | 1 | 1.3 |
| | 2 | 8.9 |
| | 3 | 41.8 |

C. Limiting Nutrient Study:

Due to significant changes in nutrient levels during shipment of the samples from the field to the laboratory, the algal assay results are not considered representative of conditions in the reservoir at the time the samples were taken (05/30/75 and 09/08/75). The reservoir data indicate nitrogen limitation at all sampling stations and times, with the exception of station 1 in July. Except for station 1 in July, all of the mean inorganic nitrogen/orthophosphorus ratios were 13/1 or less, and nitrogen limitation would be expected. The ratio of 21/1 at station 1 in July indicates phosphorus limitation.

## IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Montana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of June when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling were provided by the Montana District Office of the U.S. Geological Survey which received the daily and monthly regulated flows for Nelson Canal from the U.S. Bureau of Reclamation.

In this report, nutrient loads for the sampled tributary were calculated using mean concentrations and mean flow.

No known wastewater treatment plants impacted the reservoir during the sampling year.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

| Source | kg P/ yr | % of total |
|---|---|---|
| a. Tributaries (non-point load) - | | |
| Nelson Canal | 7,295 | 95.5 |
| b. Minor tributaries & immediate drainage (non-point load) - | - | - |
| c. Known municipal STP's - None | - | - |
| d. Septic tanks * - | 15 | 0.2 |
| e. Known industrial - None | - | - |
| f. Direct precipitation** - | 325 | 4.3 |
| Total | 7,635 | 100.0 |

2. Outputs -

| | | |
|---|---|---|
| Reservoir outlet - | Nelson Canal | 45 |
| | Nelson South Canal | 1,295 |
| | Total | 1,340 |

3. Net annual P accumulation - 6,295 kg.

* Estimate based on 50 shoreline dwellings (field limnologists observations); see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

| Source | kg N/ yr | % of total |
|---|---|---|
| a. Tributaries (non-point load) - | | |
| Nelson Canal | 134,975 | 86.8 |
| b. Minor tributaries & immediate drainage (non-point load) - | - | - |
| c. Known municipal STP's - None | - | - |
| d. Septic tanks* - | 635 | 0.4 |
| e. Known industrial - None | - | - |
| f. Direct precipitation** - | 19,920 | 12.8 |
| Total | 155,430 | 100.0 |

2. Outputs -

| | | |
|---|---|---|
| Reservoir outlet - | Nelson Canal | 1,660 |
| | Nelson South Canal | 79,745 |
| | Total | 81,395 |

3. Net annual N accumulation - 74,035 kg.

* Estimate based on 50 shoreline dwellings (field limnologists observations); see Working Paper No. 175.
** See Working Paper No. 175.

D. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

| | Total Phosphorus | | Total Nitrogen | |
|---|---|---|---|---|
| | Total | Accumulated | Total | Accumulated |
| grams/$m^2$/yr | 0.41 | 0.34 | 0.4 | 4.0 |

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Nelson Reservoir:

| | |
|---|---|
| "Dangerous" (eutrophic loading) | 0.36 |
| "Permissible" (oligotrophic loading) | 0.18 |

## V. LITERATURE REVIEWED

Horpestad, Abe, 1974. Personal communication (reservoir morphometry). MT Dept. of Health & Env. Sci., Helena.

Martin, R. O. R.; and Ronald L. Hanson, 1966. Reservoirs in the United States. Water Supply Paper No. 1838, U.S. Geol. Surv., Wash., DC.

Pike, George M., 1974. Personal communication (regulated flow in Nelson Canal). U.S. Geol. Surv., Helena.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

# VI. APPENDICES

## APPENDIX A

## LAKE RANKINGS

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# APPENDIX B

## CONVERSION FACTORS

## CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107 x $10^{-4}$ = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

# APPENDIX C

# TRIBUTARY FLOW DATA

20

# APPENDIX D

## PHYSICAL and CHEMICAL DATA

# APPENDIX E

# TRIBUTARY DATA

[illegible]

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